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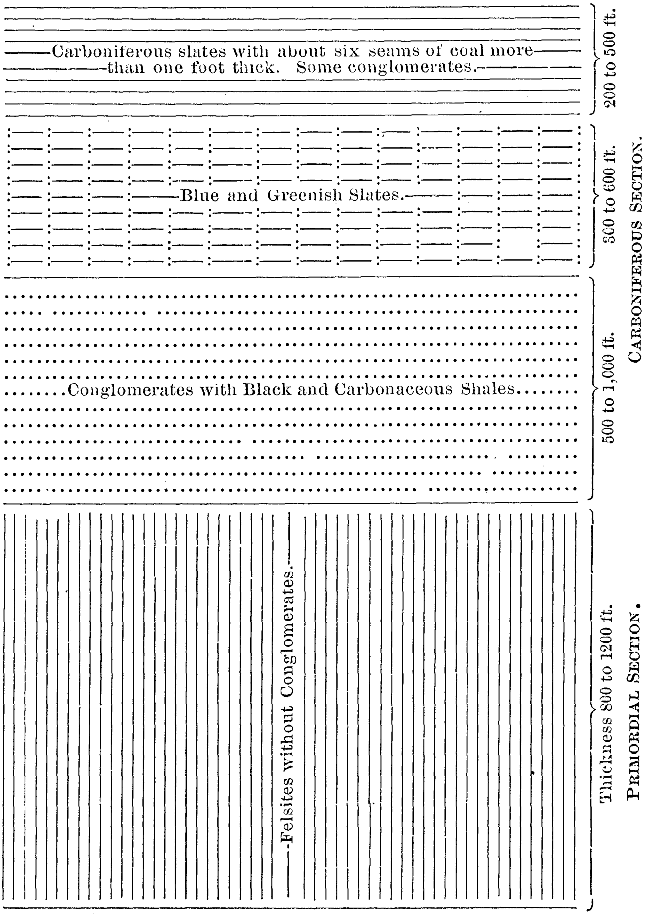
one effect of this lowering, retardation or degradation is the production of the male rather than the female sex. Some facts, at least, in the animal kingdom, as we have seen, support the same view; but to give a statement of this kind the form and validity of a law would require a much more extensive survey of correlated facts. At all events, we do not find the frequent superiority of the masculine sex in certain particulars in the higher animals necessarily incompatible with this; since this superiority prevails usually in apparatus not of the functions of the *vegetative* or organic life, but of *animal* life or of relation; as of *intellection*, *motor* power and *voice*. Beauty of plumage in birds, while we naturally attribute to it a certain superiority, may not, in the scientific sense, unequivocally have this character. If it should be conceded that it has, we must then regard its general predominance in males as one of the difficulties in the way, at present, of any extended or final generalization upon the subject. (The remainder of the paper was occupied with the application of the same course of reasoning to the study of the law of increase of human population.)

ON THE GEOLOGY OF THE ISLAND OF AQUIDNECK AND THE NEIGHBORING PARTS OF THE SHORES OF NARRAGANSET BAY.—No. III.

BY PROF. N. S. SHALER.

Physical Conditions of the Carboniferous Time.—The island of Aquidneck is so far separated from the mainland that we cannot directly refer by traced contact any of its rocks to the masses of the shore. It is not difficult, however, to find a dating point in the materials of the island itself. The extensive coal deposits with their abundant carboniferous fossils make us reasonably sure that a large part of the island is composed of rocks which were laid down at the time when the great coal fields of other parts of the continent were being formed. As the rocks of this part of the section are much better determined than those of any other part of the island, it will be well to begin with them and from them to go to those which cannot be so readily placed in their proper positions in the succession of deposits.

Over all the section extending from the Bristol Ferry to the northern end of Lilly pond, we have a set of rocks which must undoubtedly be referred to the carboniferous age, but which vary in some regards from the typical rocks of that age in this country. The exact thickness and the composition of all the members of this series are not easily ascertained on account of the limited nature of exhibitions of strata on the island. The following section is believed, however, to give something like an approximation to the truth :—


Carboniferous slates with about six seams of coal more than one foot thick. Some conglomerates.
200 to 500 ft.
Blue and Greenish Slates.
300 to 600 ft.
Conglomerates with Black and Carbonaceous Shales
500 to 1,000 ft.
CARBONIFEROUS SECTION.
Felsites without Conglomerates.
Thickness 800 to 1200 ft.
PRIMORDIAL SECTION.

The thickness of this section is difficult to determine; the numerous faults which are apparent in the small part of the area of the island, where they can be well determined, makes it likely that many occur in the region which is so deeply covered with drift that the observer cannot have a chance of measuring the disturbances they produce.

At the time when the carboniferous beds of the uppermost part of this section were formed, the shore at this part of the continent was not far from its present position. The presence of large quantities of conglomerate with water-worn pebbles in the lower part of the same section conclusively proves this point. From the carboniferous sea an arm or bay having a width of from six to ten miles extended to the northward, with considerable variation in width, as far as Worcester. It is evident that this bay was the estuary of a considerable river, probably a stream of far greater dimensions than any of those which now empty into Narraganset Bay. Down this bay there came at successive times large quantities of detrital materials which varied much in character during the two divisions of the period. During the time of the deposition of the conglomerates there was an immense transportation of fragments from some points in the interior to this shore region. The variety in the chemical and mineralogical constitution of these pebbles is, considering the great tendency there is to equalize their characters by metamorphism, exceedingly great. Some of the materials can be recognized as now in position in the region to the northward but by far the larger part are from rocks which do not, so far as known, occur in the neighborhood. The syenite and other felspathic rocks of the Bristol Neck sections are found in abundance. Other types of syenites also occur which cannot be so easily referred to any bed rock; some geologists have found fragments of Lingulæ in argillaceous pebbles of this formation. These are not known to occur in any rocks to the northward nearer than the Champlain region; it is more reasonable to believe, however, that the source of supply of these fossils has long since been destroyed by erosion, than to suppose that they have been transported from so remote a point. It is quite in accordance with what we know of the erosion of these old rocks to suppose that great masses of these fossil bearing rocks may have been in the immediate neighborhood at the time when these conglomerates were formed and yet these fragments in the newer rock remain the only record of their having existed.

In this view of their history, these conglomerate beds become a most important source of information concerning the ancient geology of this part of the continent. The geologist, in studying the character of glacial drift on this island or any other part of the continent, easily becomes convinced that he has in that mass a key to the geology of the country for sixty miles or more to the northward. Much of the rock within that region whence came this débris is now hidden by similar accumulations of glacial materials, so that the most painstaking student may fail to find its true character, but each gravel or boulder bed is a museum wherein the north lying rocks are more or less well represented. By examining a number of such exposures of the drift it is possible to determine with accuracy the range in character of materials which would be found in the region to the northward so far as Worcester or the neighborhood of Boston. In the same way we may interrogate the conglomerate of the coal period in this region for information concerning the character of the materials of that time exposed to erosive action in this part of the continent. The answer to this inquiry is that the surface of the country was then made up of syenites, porphyries, felsites, argillites and related rocks much as at the present day; some of these rocks contained fossils which may well have lived during the primordial time when they were formed. It is perfectly clear, however, that within the region where these pebbles were formed, there were no rocks of Silurian or Devonian age, else their evident fossils would have been preserved as well as the linguæ in the pebbles of the conglomerate. This argument gives an important confirmation of the view held by some American geologists, but hitherto resting on insufficient foundation, that New England was elevated above the level of the ocean before the close of the Silurian period. As the region between Newport and the Boston and Albany Railroad contains an assemblage of rocks which may be taken as representative of a large part of the rocks of Massachusetts, it may be regarded as probable that we had, at the time when this conglomerate was deposited, the same conditions prevailing among the rocks of that state as now prevail there. The work of metamorphism which has so much affected the character of the rocks of this region was already done at this the beginning of the coal period. The syenites which have been brought to the surface by the old dislocations which have given the character to the topography of New England were already in a position * to be exposed to erosion.

We have already noticed the close similarity observable between the conglomerate of the primordial time and that which has been produced during the last geological period. It is not easy to find any sharp line of demarcation between the characters of these two detrital rocks. The older conglomerate is always more compact and has usually a trace of bedding, though this feature is often wanting. The pebbles are rather more regularly arranged even where the distortion of the pebbles (a point to be treated hereafter) is least or entirely wanting. Traces of an arrangement of the pebbles as if they had been under flowing water are evident. The fact that at certain points the pebbles have had most, if not all, of the sand and clay washed away between them is a strong proof of their having been exposed to a degree of washing which has been unfelt by more modern deposits. The great similarity in the characters of these two conglomerates, the recent glacial and the carboniferous beds, is strong evidence of relation of origin. The conditions under which conglomerates can be formed are few and peculiar; mountain torrents or the sea rolling upon a shore of rock may form very local accumulations of this nature, but mountain torrents can only make band-like beds or heap up their débris in delta accumulations where their rapid streams merge in water of less carrying force. The sea cannot move pebbles except within the narrow range of its breakers; it rarely has tidal currents which can sweep coarse sand along. The only agent we know to have been generally in action on the earth which is capable of moving pebbles in such a manner as to produce broad deposits of boulders is ice. That it is able to do such work is fully shown by the great accumulations of the drift period. The researches of Mr. James Croll have shown that the conditions which were probably instrumental in producing the last glacial period have operated again and again in the past to effect the same result. There are many points in the great geological section which

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* Should it be proven that these Rhode Island conglomerates are of the same age as the materials of similar character in the neighborhood of Boston, we may be able to extend much further this system of reasoning. But it is more than likely, as I shall try to show in the discussion of the geology of Massachusetts Bay, that the conglomerates found there are of still earlier age, having probably been formed during the later stages of the primordial time. Should this conjecture prove true the character of the materials composing these beds will prove an even more interesting key to the ancient history of New England.

show, in the character of the deposits or in the physical condition of the boulders they contain, indubitable evidence of some action other than those usually operative on the surface of the earth. Wherever, as in the nägelfluh of Switzerland or other similar accumulations, we have wide extending shells of boulders and gravel, we are clearly justified in suspecting ice action, when, as in all cases of conglomerates of wide geographical extension which I have examined, the pebbles are not formed with the regular outlines which necessarily occur where the shaping of the masses is the result of moving water. We are bound to believe that pebbles of all sizes, which have been worn to their shape by running water, must tend to assume regular forms, the major axis of which will be coincident either with the greater lengths of the pebbles or with their lines of greatest hardness.

In any case the pebbles will generally assume more or less oblately spheroidal forms. On the other hand, materials which have received their shapes under glacial action will generally be free from those results which come from the uniform friction of one pebble against another, inasmuch as such movements will be impossible while the fragments are in the grip of the ice. The nature of the conditions is such that the pebbles will be worn by being held in a fixed position with one side turned to the abrading agent, the others being for the time protected from wear. With the constant changes occurring in the moving ice one pebble will frequently come to have several facets cut upon it in this way, and many pebbles in succession will be subjected to the same sort of wear. In accumulations of unaltered glacial deposits we always find pebbles having this many faceted character which results from the successive wearing. The only difficulty is that many, often by far the larger part of the mass, are made up of pebbles which have gotten their shape without actual attrition, being simply rounded by chemical action, or keep their original form; but, in any case where many pebbles with a faceted character occur in a conglomerate it may be safely concluded that it has been formed by ice action.

Pebbles having the above described characters occur in abundance throughout the unaltered part of the conglomerate which underlies the Rhode Island coal. This with the other features may be taken making it pretty nearly certain that it had a glacial origin. It must be noticed, however, that in no case have the pebbles, which have been observed, retained their scratches. In view of the fact that the larger part of our drift beds do exhibit this characteristic in some of their pebbles it must be allowed that this seems a serious difficulty in the way of the hypothesis that the conglomerate pebbles were formed by glacial agency. It is to be noticed, however, that all these conglomerates show the effects of water action in the rearrangement of the fragments and can only be compared with that part of our drift along our shores which has been rearranged in a similar manner. We find on examination that all those beds of drift pebbles which come within the submergence left on our shores have lost the traces of ice action which they generally bear on their surfaces; the facet-like faces are retained, but the scratches are, in all the instances which I have examined, quite worn away. Moreover, the boulders of this ancient period have undergone so much pressure even in those cases where there has been no great mineralogical change, that in almost all the localities which I have examined, distinct marks of change in form are quite evident. Such changes would necessarily have been accompanied by obliterations of such fine exterior markings as glacial scratches. Taking the assemblage of characters observable in this conglomerate, I am inclined to think that it was formed in great part beneath the level of the water, the pebbles and cement being transported by glacial agency and deposited in the ancient sea just as they are now being carried and deposited by the glacial streams on the Greenland coast.

The connection between the carboniferous period and a preceding epoch favoring the deposition of extensive beds of conglomerate is a fact well established both in this country and Europe. The conglomerate and grits which underlie the coal are generally made up of materials which appear to have been transported for considerable distances. This detrital epoch which is so generally indicated by the subcarboniferous formations can best be accounted for by supposing that the forest period of the carboniferous age was preceded by a glacial period of great duration and intensity. During this ice time and immediately succeeding it there would have been, along the shallow border waters of the old continents, great accumulations of pebble beds and sandstones, which would show throughout the stratifying action of water. During the period of reelevation, which would have followed an ice time then, as it followed the ice time which has just passed away, these beds of stratified drift would have become covered with a luxuriant vegetation which was in time to be converted into the beds of coal in which its remains have been entombed. The present geological period is a carboniferous period, and in time its coal beds will be found resting upon just such a section as now characterizes the rocks of the ancient coal time. The Dismal Swamp, when it is converted into coal, as it well may be in the future, will show a drift section beneath it where the conglomerates will be composed of pebbles which owe much of their transportation to ice action, though their final arrangement is the work of water. It may be asked why do we not have the unstratified drift and the scratched pebbles of the glacial period which preceded the carboniferous epoch; the answer is easy to find, the shore regions of any continent when the successive submergences keep up the process of deposition, are the only parts of its surface where we can expect to find a record of ancient conditions long before anything like the time has elapsed which has rolled away since the carboniferous period, or the unstratified drift of our shores may have disappeared, leaving only such imperfect record as may be perceived in the bedded conglomerate which may happen to be buried beneath succeeding deposits. The conjunction of conglomerates and coal beds is not limited to the carboniferous period. I am unacquainted with the history of the jurassic and cretaceous coals which occur at various points, but in the tertiary period we see at least twice the same swift change from the desolation of glacial conditions to luxuriant vegetation, which is shown in the period in which we now live, and which I have suspected in the carboniferous time.

The cause of these sudden transitions in climatic conditions is yet to be explained. Apart from the question of the origin of the glacial periods of the past which cannot be discussed here, it is easy to see that the glacial period which has just passed away has done much to favor the development of a luxuriant vegetation over a large part of the country it affected. In the first place the ice work of the glacial time was effective in producing a large amount of well ground material. The surfaces it covered were probably reduced to a state fit for assimilation by plants at a very much more rapid rate than would else have taken place in the same regions under the existing conditions; it must also be noted that the supply of nutriment from the rocks is very much more rapid on a soil filled with glacial material than in one where the action is by atmospheric erosion alone; every pebble in a gravelly soil wastes over its whole surfaces, so that the aggregate area of supply whence plants can draw their nutriment is many times greater than if it all came from the wearing of the bed rock. There is also the mingling of materials which took place during the glacial period, which has not been without effect in increasing the productiveness of soils. This action has brought into each cubic foot of our boulder clays a great assortment of diverse materials giving a soil ready for the nutrition of any seeds which fall upon it. However varied the demand, it would be sure to find the materials at hand. During the glacial period there was no vegetation in the drift covered region for a period of time which must be reckoned by thousands if not hundreds of thousands of years, so that the materials which came into an assimilable condition remained unappropriated by plants and were in a fashion stored for their future use; when the ice sheet passed away, the soil was left with a rich store of materials suitable for the nutrition of plants. It may be that the vigor of the carboniferous vegetation was in part the result of this glacial preparation of the earth's surface for vegetable life.

The whole time of the formation of this conglomerate was a period of recurring changes of condition. The pebble beds alternate with sandstones and shales and occasionally with somewhat carbonaceous layers of slate. At one point, Wood's Castle, on the eastern shore of the island, the conglomerate is immediately overlaid by carbonaceous shale with faint traces of coal plants; above the coal comes a greenish shale of an unknown thickness. It may be said by some that the juxtaposition of carbonaceous beds makes the glacial origin of the conglomerate doubtful. That this reasoning would be fallacious is well shown by the fact that in New Zealand we have a vegetation more closely allied to that of the carboniferous period than is found in almost any other region growing in the immediate neighborhood of the glaciers. Very slight changes in the conditions prevailing there might bring a vegetation of palms and tree forms upon the débris of the ice streams.

The history of these conglomerates would not be complete without a consideration of the often noticed and much misunderstood compression of the pebbles. The pebbles which make up a large part of the conglomerate which lies to the south of Easton's Beach and that which is found in the neighborhood of Taunton are usually so nearly in the condition in which it was originally formed that even the accustomed eye fails readily to detect any change in its structure, from compression. At other points to the northward the distortion of the elements which compose the conglomerate is very great indeed. The inquiry into the history of this great change must be made in connection with our study of the dynamic history of the beds of the island.

REVIEWS AND BOOK NOTICES.

THE EVOLUTION OF LIFE.* — An exceedingly interesting and suggestive book, as it is so full of the spirit of Hæckel's writings, of which it is in large part a condensation. We doubt not that it will be extensively read by those interested in natural history studies, though more especially designed to place before the general reader "a condensed view of the evidences for the theory that the animal and vegetal worlds have been very gradually developed or evolved, as distinguished from the hypothesis of their sudden special creation." For the purpose of popular exposition the author's style is excellent, being simple and concise. As we suggested, the work is a reflection of Hæckel's "History of Creation," a remarkable book by a remarkable man. The successor of Oken at Jena, he partakes largely of his spirit, and with much that is strikingly original and suggestive in his popular works, there are portions that are highly exaggerated, facts being sometimes strangely twisted to suit his theory. Hæckel's guesses and assumed intermediate types may be in many cases proved true years hence, but the history of evolution cannot be written by one man in a single century. The "Evolution of Life" must be judged by the same canons of criticism. The impression made on our mind after examining it is, that the author is far more sure of his deductions and grouping of facts than would be a specialist in any one of the classes of animals, whose supposed genealogy he indicates in some cases, at least, with a degree of overconfi-

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*Evolution of Life. By H. C. Chapman, M.D. Philadelphia, J. B. Lippincott & Co. 1873 (received Oct. 9, 1872). 8vo. pp. 193. With diagrams and plates. $4.00.